Foreword

National Oceanic and Atmospheric Administration

U.S. DEPARTMENT OF COMMERCE

NOAA Fisheries Service
Northeast Cooperative Research Partners Program

The National Marine Fisheries Service (NOAA Fisheries Service), Northeast Cooperative Research Partners Program (NCRPP) was initiated in 1999. The goals of this program are to enhance the data upon which fishery management decisions are made as well as to improve communication and collaboration among commercial fishery participants, scientists and fishery managers. NOAA Fisheries Service works in close collaboration with the New England Fishery Management Council's Research Steering Committee to set research priorities to meet management information needs.

Fishery management is, by nature, a multiple year endeavor which requires a time series of fishery dependent and independent information. Additionally, there are needs for immediate short-term biological, oceanographic, social, economic and habitat information to help resolve fishery management issues. Thus, the program established two avenues to pursue cooperative research through longer and short-term projects. First, short-term research projects are funded annually through competitive contracts. Second, three longer-term collaborative research projects were developed. These projects include: 1) a pilot study fleet (fishery dependent data); 2) a pilot industry based survey (fishery independent data); and 3) groundfish tagging (stock structure, movements and mixing, and biological data).

> First, a number of short-term research projects have been developed to work primarily on commercial fishing gear modifications, improve selectivity of catch on directed species, reduce bycatch, and study habitat reactions to mobile and fixed fishing gear.
>
> Second, two cooperative research fleets have been established to collect detailed fishery dependent and independent information from commercial fishing vessels. The original concept, developed by the Canadians, referred to these as "sentinel fleets". In the New England groundfish setting it is more appropriate to consider two industry research fleets. A pilot industry-based survey fleet (fishery independent) and a pilot commercial study fleet (fishery dependent) have been developed.
>
> Additionally, extensive tagging programs are being conducted on a number of groundfish species to collect information on migrations and movements of fish, identify localized or subregional stocks, and collect biological and demographic information on these species.

For further information on the Cooperative Research Partners Programs please contact:

National Marine Fisheries Service (NOAA Fisheries Service)
Northeast Cooperative Research Partners Program

(978) 281-9276 – Northeast Regional Office of Cooperative Research
(401) 782-3323 – Northeast Fisheries Science Center, Cooperative Research Office, Narragansett Laboratory

www.nero.noaa.gov/StateFedOff/coopresearch/

TESTING BYCATCH

in an

OBSERVER-BASED EXPERIMENTAL SHRIMP FISHERY

conducted in an

AREA OF HIGHER GROUNDFISH CONCENTRATION

May, 2001

Funded by:

NATIONAL MARINE FISHERIES SERVICE
COOPERATIVE RESEARCH PARTNERS INITIATIVE

In cooperation with

NEW ENGLAND FISHERY MANAGEMENT COUNCIL
RESEARCH COMMITEE

Completed by:

MAINE DEPARTMENT OF MARINE RESOURCES
F/V DEE DEE MAE II, F/V MISS PAULA, F/V BAD PENNY
F/V JULIE D, F/V LESLIE ANN, F/V SUSAN & CAITLYN
GULF OF MAINE AQUARIUM

July 28, 2003

DRAFT SUBJECT TO REVIEW BY NEFMC RESEARCH COMMITTEE

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ACKNOWLEDGEMENTS

Planning and implementation of this research project, titled ***Testing Bycatch in an Observer-based Experimental Shrimp Fishery Conducted in an Area of Higher Groundfish Concentration***, was made possible by the combined efforts of numerous individuals and agencies. At the risk of overlooking someone, we would like to thank the following for their hard work bringing this project to fruition:

Dan Schick, Maine Department of Marine Resources, for his authorship of the project funding proposal, scientific advice and oversight, assistance with vessel selection and state permitting, analysis of shrimp samples, analysis of data and co-writing the final report.

Maggie Raymond, Associated Fisheries of Maine, for her initiative to bring the Maine Department of Marine Resources and the Gulf of Maine Aquarium together as partners to fund the project, her assistance with federal permitting, and her communication with industry.

Stan Coffin of the *F/V Bad Penny*, Lendall Alexander of the *F/V Julie D*, Marshall Alexander of the *F/V Dee Dee Mae II*, Steve Jordan of the *F/V Leslie Ann*, Terry Alexander and Steve York of the *F/V Miss Paula*, and Craig Pendleton and Mike Stinchfield of the *F/V Susan & Caitlyn* for sharing their knowledge of the shrimp fishery, attending numerous project planning meetings, and providing their vessels as research platforms.

Phil Yund, University of Maine and National Science Foundation, for his scientific advice planning the experimental design of the project and selecting vessels for the project.

Earl Meredith, National Marine Fisheries Service Northeast Cooperative Research Program, for his coordination of communications with NMFS staff concerning project budget and preliminary data analysis matters.

Tom Warren, National Marine Fisheries Service, Northeast Regional Office, for his prompt follow through and communication regarding exempted fishing permit issues.

Ed Emmons, Carey Gregor, Jim Davenport, James Becker, Jim Doucette, and David Gallagher for their professional service as observers/sea samplers.

Gulf of Maine Aquarium
July 28, 2003

EXECUTIVE SUMMARY:

Working in cooperation with six shrimp vessels and the Maine Department of Marine Resources, the Gulf of Maine Aquarium has completed a collaborative research project titled ***Testing Bycatch in an Observer-based Experimental Shrimp Fishery Conducted in an Area of Higher Groundfish Concentration***.

The goal of the Experimental Shrimp Fishery research project was to determine whether a shrimp fishery could be conducted southeast of the Loran 25600 line within acceptable bycatch limits in order to provide additional economic opportunity to the shrimp fleet and alleviate pressure on shrimp in inshore waters.

During May 2001, six commercial shrimp vessels completed two trips each of three days duration (except for one vessel trip curtailed by equipment failure) in waters southeast of the Loran 25600 line in the vicinity of Cashes Ledge (west to 69º40'W, east to 68º30'W, south to 42º30'N). The vessels completed a total of 130 commercial tows (average length of approximately 2 hours) with a 1" Nordmore grate and 24 control tows (average length of approximately 30 minutes) without the grate. Key findings were as follows:

Data Summary:	Tows with Grate	Control Tows without Grate
Total Catch (lbs.)	78,776.3	16,395.1
Total Whiting Catch (lbs.)	71,904.8	6,650.2
Total Shrimp Catch (lbs.)	1,943.8	64.7
Total Regulated Species Catch (lbs.)	1,407.2	5,432.2
Total Bycatch Regulated Species	1.8%	33.1%
Number of Tows (n)	130	24
Average Total Catch per Tow (lbs.)	605.9	683.1
Average Shrimp Catch per Tow (lbs.)	15.0	2.7
Average Regulated Species Catch per Tow (lbs.)	10.8	226.3
Average Bycatch per Tow	2.9%	32.2%
Standard Deviation Average Bycatch per Tow	3.5%	26.6%
Relative Standard Error (RSE = SE/Mean)	10.9%	16.8%
Median Bycatch per Tow	1.6%	21.1%
Average Total CPUE per Tow (lbs./hr.)	295.8	1,748.4
Average Shrimp CPUE per Tow (lbs./hr.)	7.2	5.4
Average Regulated Species CPUE per Tow (lbs./hr.)	5.1	701.1

The mean % bycatch of regulated species in tows using the Nordmore grate, 2.9% +/- 3.5%, was significantly ($t = 6.664$, $P(\text{Mean } X = 5\% << 0.001)$ below the 5% threshold for regulated species, despite the minimal catches of shrimp. The comparative bycatch and CPUE data from Nordmore grate tows vs. control tows without the grate indicate that the Nordmore grate was effective at minimizing bycatch of regulated species present.

The low catch of shrimp was disappointing, but does not invalidate the fact that fishing the net with the Nordmore grate outside the 25600 line produces very low bycatch of

regulated species, which is the aim of the conservation effort for groundfish. The low shrimp catch was the result of the small 1998 year class of male shrimp (smallest on record since the 1983 inception of the summer ASMFC Shrimp Survey) and a delayed offshore migration of female shrimp. In a "normal" year for the May shrimp fishery, Maine Department of Marine Resources port sampling records indicate that shrimp catch per unit effort in that area would be closer to 180 lbs./hr (range 49 – 333 lbs./hr).

BACKGROUND:

The original National Marine Fisheries Service (NMFS) testing of the Nordmore grate to minimize bycatch in the northern shrimp (*Pandalis borealis)* fishery was all done inside the Loran 25600 line, which is the offshore boundary of the Small Mesh Exemption Area. The 25600 Line was chosen as the southeastern boundary for the Small Mesh Exemption Area for four reasons: (1) it set limits as to where the small mesh vessels would be located, making overflight enforcement manageable; (2) the area northwest of the 25600 line was the area most likely to be fished using small mesh given that most shrimp trips were day trips; (3) the area northwest of the 25600 line was believed to contain fewer groundfish than the area outside the line; and (4) a Loran line roughly parallel to the coast was a convenient boundary all parties would understand. The line was established before the Nordmore grate was developed and bycatch was a problem.

While the original logic for establishing the Small Mesh Exemption Area's southeastern boundary at the Loran 25600 Line made sense at the time, the suitable bottom for shrimp does not follow a linear boundary and the nature of the shrimp fishery has changed over recent years due to changes in regulations, technology, and shrimp behavior. Further, the Nordmore grate minimizes the effect of a small mesh fishery on groundfish stocks. The spring shrimp fishery has evolved to a fishery where two and three-day trips are commonplace. Shrimp vessels are ranging farther from shore. In light of these changes, Gulf of Maine shrimp vessels would like to access a body of shrimp that in a normal year is resident in (transitionals), or migrates to (females) an area outside the Loran 25600 Line in the late spring (May and June).

In response to a request from the ASMFC Northern Shrimp Industry Advisory Board, the Northern Shrimp Section requested that the New England Fishery Management Council (NEFMC) either move the outer limit of the Small Mesh Exempted Fishing Area outward beyond the Loran 25600 line or abolish it altogether. NEFMC, in return, has asked ASMFC to show proof that the proposed fishery would at least remain as clean as the current shrimp fishery in terms of meeting the 5% bycatch limit on regulated groundfish species. This discussion was the stimulus for the funding and implementation of the May, 2001 Experimental Shrimp Fishery research project.

Of background interest, the NMFS/ASMFC Cooperative Shrimp Survey has shown a consistent pattern of a sizeable body of shrimp just outside the Loran 25600 line near Cashes Ledge. (Prior to the Loran 25600 line restriction, harvesters traditionally conducted a May/June fishery in this area). This body of shrimp is within the survey's Stratum 8, which is one of the strata used in producing the annual shrimp assessment. Thus this body of shrimp has always been considered when formulating the Northern

Shrimp Technical Committee's advice to the Northern Shrimp Section for harvest levels in the next season's fishery.

The May, 2001 Experimental Shrimp Fishery research project was proposed to test whether the Gulf of Maine shrimp fleet can fish for shrimp outside of the Loran 25600 Line during the month of May while meeting the limit of 5% by weight bycatch of regulated groundfish species.

PROJECT PLANNING AND DESIGN:

Vessels:

Vessel selection was completed in January, 2001 through a competitive RFP process. Twelve vessels submitted proposals; six vessels were selected. The vessels included the F/V Bad Penny (Boothbay Harbor), F/V DeDee Mae II (Biddeford), F/V Julie D (Cundy's Harbor), F/V Leslie Ann (Portland), F/V Miss Paula (Cundy's Harbor) and F/V Susan & Caitlyn (Saco). The six vessels, Dan Schick from the Maine Department of Marine Resources (MEDMR), Maggie Raymond from Associated Fisheries of Maine, and Gulf of Maine Aquarium (GMA) staff have worked closely from January through May to develop our area sampling strategy and execute a series of successful experimental fishing trips.

Observers:

Observers were recruited and hired directly by the Gulf of Maine Aquarium in order to insure the observer quality and commitment in the context of a tight northeast observer market. Observers were required to have completed a NMFS observer training and served in prior observer assignments or to have served successfully as an observer/sea sampler in the MEDMR Inshore Trawl Survey. The Manomet Observatory was retained to provide a one-day training course to insure that all observers were current in their familiarity with sampling protocols and understood the specific observer/sampling requirements of the Experimental Shrimp Fishery research project.

Permits:

In April, the National Marine Fisheries Service issued Exempted Fishing Permits to the six vessels to conduct the experimental fishery. The Maine Department of Marine Resources issued a Special License to the six vessels and eleven seafood processors to land and process shrimp, with all proceeds from the sale of shrimp being paid to the Gulf of Maine Aquarium to offset the cost of the project.

Experimental Shrimp Fishery Design & Implementation:

The experimental fishery design was to conduct a total of 12 three-day trips during the month of May. This month was chosen because it is the traditional month for the offshore spring shrimp fishery. Thus understanding the bycatch of regulated species at this time of year is paramount. Half of the trips were scheduled for early May and half of

the trips were scheduled for late May in order to complete an initial sample of tows in the area, process catch data to assess bycatch impact on regulated species, and then, if bycatch was below 5%, complete a second sample of tows in the area. The six vessels were organized into two groups of three vessels, one group for the first half of May and the other for the second half of May. Each vessel group was scheduled to complete two back-to-back trips of three days duration, with one layover day between trips. All trips were 100% observer covered.

The area of the Experimental Shrimp Fishery was divided into 10 minute squares and vessel Captains were encouraged to sample in each square. Each vessel focused on one third of the area (east of Cashes Ledge, in and northwest of Cashes Basin, west and northwest of Fippennies Ledge). In an effort to balance wide area coverage and the catch of shrimp that would be produced by commercial effort during each trip, each of the three vessels completed initial tows in shrimp habitat across as large an expanse of their area as possible and then focused their remaining tows on the most promising locations to find shrimp. (See Figures 1-3 on pages 8-10 for tow locations overall, by trip and by vessel.) The catch from all tows was sorted by the observer, sampled as appropriate, weighed and measured by species at sea (except for shrimp, where samples were preserved for analysis by MEDMR staff onshore). For analysis, a null hypothesis was formulated: Ho = The bycatch of regulated species was the same as, or greater than 5%. This would be tested by either a two tailed, or a one tailed test utilizing Student's 't' (Zar, p. 90). The alternative hypothesis (Ha) would be that the mean bycatch of regulated species would be less than 5%. The 't' test is considered fairly robust to some deviation from normality.

Initially, the scientific and fishing industry partners in the project decided to forego control tows in light of the well-documented effectiveness of the Nordmore grate and in order to maximize the sample size of Experimental Shrimp Fishery tows. Following the first trip and in light of the low catch rate of shrimp by each vessel on that trip, control tows were added to the experimental design in order to determine whether the low bycatch rates were due to the effectiveness of the Nordmore grate or to a lack of regulated species present in the area. Control tows were expected to catch significantly more finfish and were therefore limited to 30 minutes duration to limit the catch of finfish. The catch composition from a 30 minute tow has been shown to be fairly representative (most research survey tows are 30 minutes or less) and thus a longer tow would produce needless mortality. Vessels 1 and 3 completed one control tow per day during their second trip; Vessel 2 did not complete control tows during her second trip due to winch motor problems that curtailed her trip. Vessels 4, 5 and 6 completed one control tow per day during both of their trips. A second null hypothesis was formulated that the bycatch of regulated species would be the same for the control tows as for tows with the Nordmore grate as the bycatch rate was caused by low concentrations of regulated species in the area. The alternative hypothesis, should the null be rejected, was that regulated species would be greater in the control tows as the Nordmore grate was indeed effective at excluding them from the net and that their concentrations were indeed greater than 5% on the bottom. The hypothesis will be tested by two-tailed 't' test if normality criteria are met, or by non-parametric means (Mann-Whitney) if they are not.

The first group of vessels (F/V DeDee Mae II, F/V Miss Paula, F/V Bad Penny) completed their two trips on the following schedule:

Trip 1: May 7-9
Trip 2: May 11-13

The F/V DeDee Mae II and F/V Bad Penny completed both trips successfully. The F/V Miss Paula completed her first trip successfully, but did not complete her second trip due to a winch motor failure (which limited her second trip to just two tows).

Based on the original project proposal and subsequent conversations between Dan Schick of MEDMR and the NMFS Northeast Region Office – Cooperative Research Partners Initiative (NERO CRPI) staff, it was agreed that after completing the first half of the fishery:

1. If bycatch of regulated species was less than 5%, the experimental fishery would continue;
2. If bycatch of regulated species was more than 5% but less than 10%, a ¾" Nordmore grate would be used for the remainder of the experimental fishery.
3. If bycatch of regulated species was more than 10%, NMFS would consider revoking the experimental fishery permit.

Following the completion of the second trip, the data from the first two trips was analyzed to determine the level of catch and bycatch of regulated species. The data from these trips indicated bycatch below 5%, although few shrimp were caught (463.6 pounds total). The first two trips resulted in 3% total bycatch of regulated species and an average 4.3% bycatch per tow of regulated species.

Thus GMA requested permission from NERO CRPI to continue the experimental fishery based on the following factors:

1. As coastal waters warmed up during May, the shrimp should accelerate their movement offshore into deep water in the study area outside of the Small Mesh Exemption Area and the Loran 25600 line.

2. Results from the first six trips indicated that the project was having minimal impact on regulated species.

3. Additional data were needed to assess whether, where, and when a shrimp fishery may be undertaken outside the 25600 Line with minimal impact on regulated species.

4. Goals of the collaborative research funds supporting this project included providing productive economic relief for fishing vessels and fostering the development of collaborative relationships between fishermen and scientists. The Experimental Shrimp Fishery research project was doing no significant harm to regulated species, so these goals were worth pursing.

NERO CRPI approval was given to continue with the second half of the experimental fishery. The second group of vessels (F/V Julie D, F/V Leslie Ann, F/V Susan & Caitlyn) completed two trips on the following schedule:

Trip 3: May 23-25
Trip 4: May 27-29

All three vessels completed the last two trips successfully.

RESULTS:

The vessels completed a total of 157 tows of which 130 commercial length tows with a 1" Nordmore grate (average length of 2 hours, 7 minutes) and 24 control tows without the grate (average length of 30 minutes) were included in the data base. See *Figure 1: Location of Nordmore Grate Tows vs. Control Tows* on following page. Two Nordmore grate tows were excluded from the database due to the grate being upside down, producing a twist in the net forward of the grate. One additional grate tow was interrupted due to hung gear.

CATCH, BYCATCH AND CATCH PER UNIT EFFORT DATA:

The details of total catch and catch per unit effort for shrimp, regulated species in aggregate and by individual species (cod, haddock, yellowtail flounder, witch flounder, American plaice or dab, pollock, winter flounder or blackback, windowpane flounder, redfish or ocean perch, and white hake), and other species for the Experimental Shrimp Fishery during the twelve trips completed by the six vessels are provided in *Exhibit A: EXPERIMENTAL SHRIMP FISHERY CATCH WITH NORDMORE GRATE*, *Exhibit B: EXPERIMENTAL SHRIMP FISHERY CATCH PER UNIT EFFORT WITH NORDMORE GRATE*, *Exhibit C: EXPERIMENTAL SHRIMP FISHERY CONTROL TOW CATCH*, and *Exhibit D: EXPERIMENTAL SHRIMP FISHERY CONTROL TOW CATCH PER UNIT EFFORT*.

Overall Fishery Data Summary:

The data indicate that a May fishery for shrimp using the Nordmore grate can be conducted in waters outside of the Loran 25600 line in the vicinity of Cashes Ledge without exceeding 5% bycatch of regulated species, as summarized in Table 1 below. The frequency of % bycatch values from tows with the grate shows a mean of 2.9% and a median of 1.6% and is skewed towards the lower values (Figure 4). The mean % bycatch of regulated species was significantly less than 5% with a one-tailed 't' test of 6.774, which is well beyond the 0.01% probability. A one tailed test was used as the normal distribution of % bycatch values was truncated by being so close to zero.

General observations about the data are as follows:

- Bycatch results for tows using the Nordmore grate tows indicate that a May shrimp fishery could be conducted in waters outside the current Loran 25600 Line boundary of the Small Mesh Exemption Area with minimal impact on regulated species as measured by percent bycatch and total pounds of regulated species caught (Figure 4).

- Significant whiting catches contributed substantially to the low regulated species bycatch results. Whiting bycatch is typical of the shrimp fishery.

- Control tow catch and CPUE data confirm that the Nordmore grate was excluding regulated species when in use (Tables 2, 3).

- Low shrimp CPUE raises the question of whether a commercial shrimp fishery is viable in the area. Low shrimp catch was due to the small 1998 male year class and delayed offshore migration of females. (See "SHRIMP CATCH DATA" discussion on page 31.)

Difference in Percent Bycatch of Regulated Species between Control and Grate Tows.

The Null Hypothesis that the two sets of tows would produce the same % bycatch was tested by both a two-tailed 't' test and non-parametric Mann-Whitney test. The 't' test is dependent on a normal distribution, but is robust to some deviation from normality. Both tests produced significant differences with probabilities well beyond the accepted 95% level. Thus the null is rejected and the reduction in bycatch is real, even with the differing numbers of tows and the greater variance around the control tow data (Table 3).

Trip Catch, Bycatch and CPUE Data Summary:

Catch and bycatch per tow results for each trip by vessel are provided below. Table 4 contains results for 130 tows completed using the Nordmore grate. Table 5 contains results for 24 control tows completed without the grate. Table 6 contains comparative CPUE data between grate tows and control tows.

Observations concerning catch and bycatch per trip are as follows:

- Vessels 1, 2 and 3 did not complete control tows during Trip 1 and Vessel 2 did not complete control tows during Trip 2 as previously discussed on page 6.

- Small control tow sample size per vessel/trip of just three tows for Vessels 1 and 3 and six tows for Vessels 4, 5 and 6 and multiple factors contributing to catch and bycatch results (vessel effect, location effect, etc.) limit interpretations that can be made of data per vessel.

- Based on observation of vessel communications during the Experimental Shrimp Fishery, lower bycatch on the second trip for five out of six vessels when using the Nordmore grate (and sixth vessel bycatch was low both first and second trips) reflects vessel Captain learning effect between first and second trip and vessel Captain attention to minimizing bycatch while searching for shrimp over the course of the two trips. Such behavior is typical in the commercial shrimp fishery as vessel Captains seek to minimize bycatch in order to produce clean hauls that require less sorting of catch on deck.

Vessel Catch & Bycatch Data Summary:

Catch and bycatch per tow results for each vessel are provided below. Table 7 contains results for 130 tows completed using the Nordmore grate. Table 8 contains results for 24 control tows completed without the grate. Table 9 contains comparative CPUE data between grate tows and control tows.

Observations about the vessel catch and bycatch per tow data are as follows:

- Vessels 1, 2, and 3 did not complete control tows during Trip 1, and Vessel 2 did not complete control tows during Trip 2 as previously discussed on page 6.

- Small control tow per vessel sample size of just three tows for Vessels 1 and 3 and six tows for Vessels 4, 5, and 6, and the multiplicity of factors contributing to catch and bycatch results (vessel effect, location effect, etc.) limit interpretations that can be made of data per vessel.

- Higher bycatch result for Vessel 1 when using the Nordmore Grate was caused by a mix of lower than usual whiting catch and slightly higher flatfish catch (See Tows 1-23 in Exhibit A).

Catch, Bycatch and CPUE by Area Fished:

The tows in this study were conducted in three main areas, east of Cashes Ledge, Cashes Basin to NW of Cashes and West of Fippennies Ledge. While vessels were generally assigned to tow in one of the three areas, not all vessel trips were confined to one area. See Table 4, location of tows by trip for a breakdown. Most of the preceeding analyses have dealt with catch and bycatch on a per trip basis. For this analysis, the tows from whatever vessel were assigned to an area based on the tow location and these results were

compiled. Table 10 shows average catch per tow, average catch per trip and average CPUE for overall catch, shrimp and regulated species for each area for both the Nordmore grate series and the Control series in both weight and numbers. Analyses for regulated species bycatch include the mean, median and range of % bycatch, standard deviation, n, standard error and relative standard error. Relative standard error is the standard error (SE) divided by the mean % bycatch. For the Nordmore grate catch per tow data, the overall catch was lowest in the East, while the shrimp and regulated species catches were about the same compared to the Central and Western Areas, producing a higher % bycatch in the East, barely under 5%. The mean bycatch was lowest in the West. The median % bycatch values were consistently lower than the mean values, indicating a skewed distribution towards lower bycatch. The relative standard errors were not too bad for the catch per tow data except for the West, where the RSE was greater than 20%. The CPUE is probably the best overall indicator for comparing the three areas. CPUE for total catch and shrimp catch was low in the East compared to the other two areas. The CPUE for the regulated species was lowest in the West, about equal for the other two areas and almost twice the catch in the West. Even so, the CPUE was still less than 7 pounds per hour towing with the Nordmore grate.

For the Control catch per tow, total catch was again lowest in the East and about equal in the other two areas. Shrimp catches were low compared to the grate tows and the regulated species catches were high. The percent bycatch of regulated species was highest in the Central Area and lowest in the West. The median values were consistently lower than the means, indicating a skewed distribution towards lower values. Relative standard errors were high, above 20% for each area, but below 20% for all tows. As with the grate tows, the best indicator is the CPUE in pounds/hour. The CPUE for total catch was highest in the Central Area and lowest in the East. Shrimp CPUE was around 11 pounds per hour in the West, but negligible in the other two areas. CPUE for regulated species was highest in the Central Area and lowest in the West. CPUE for the control tows was much greater for total catch and for regulated species catch than for the grate tows, but lower for shrimp catch. The data show that the net with the Nordmore grate maintained low regulated species bycatch, 3.5 to 6.4 pounds per hour towing and below 5% in each area in the presence of significant amounts of regulated species, which ranged from 528 to 858 pounds per hour towing.

Nordmore Grate Tows with Percent Bycatch of Regulated Species Greater than 5%

In each area there were some tows made with the Nordmore grate that were higher than 5% in percent bycatch of regulated species. As most tows were very low in % bycatch of regulated species in each area (Figure 5) it is meaningful to examine those tows that were high to look for causes. Figure 6 shows the characteristics of these tows in overall catch, bycatch and percent bycatch and the individual regulated species relationship to the percent bycatch in separate graphs for each area. The tows with greater than 5% bycatch were ranked in ascending order of % bycatch to see the relationship between total catch and regulated species bycatch.

In the Eastern Area, the total catch declines and the regulated species remains relatively constant as % bycatch increases. In the highest % bycatch tow, both catch and regulated species bycatch are high, thus the % bycatch doesn't increase markedly. The cause of that high bycatch is a large (7X) increase in the catch of grey sole from an average of about 3 pounds/tow to over 20 pounds. In general, however, the increase in % bycatch in the Eastern Area is caused by a decrease in total catch, rather than an increase in the bycatch of regulated species.

In the Central Area, the % bycatch doesn't increase substantially over 5% for all 10 tows that were over 5%. The total catch and bycatch of regulated species both change about the same amount. Whether the slight increase in % bycatch over the 10 ranked tows is caused by increase in bycatch or a decrease in total catch is impossible to determine.

In the Western Area, there were only three tows over 5% and only one of those was over by very much. In this tow, the increase in % bycatch was caused by a marked decline in total catch from an average of over 250 pounds to around 50 pounds while the bycatch of regulated species followed the trend, but didn't decline nearly as much. In that tow, the regulated species catch showed a marked rise in American Plaice bycatch from an average of less than 2 pounds to almost 9 pounds, but an even greater decline in redfish bycatch from an average of about 13 pounds to about 1 pound. Again, the large increase in % bycatch was more a function of reduced total catch than an increase in regulated species bycatch.

Whiting and Red Hake:

While the focus of this Experimental Shrimp Fishery was to test whether a shrimp fishery could be conducted with minimal bycatch of regulated species southeast of the current Loran 25600 line and the focus of data analysis has been on the catch of shrimp and regulated species, it is important to note the impact of the fishery on whiting and red hake:

- The whiting catch during the 130 tows using the Nordmore grate totaled 71,904 lbs. (average of 553 lbs/tow or CPUE of 264 lbs./hr.). As noted during in the Data Summary section, significant whiting bycatch is typical in a shrimp fishery.

- The red hake catch during the 130 tows using the Nordmore grate totaled 2,854 lbs. (average of 22 lbs./tow or CPUE of 11 lbs./hr.).

The numbers of individual fish of each of the regulated species harvested during the Experimental Shrimp Fishery are provided below.

LENGTH FREQUENCY DATA

Length frequency data for Cod, Haddock, Pollock, American Plaice, Gray Sole, White Hake, Redfish, Silver Hake, Red Hake and Spiny Dogfish are provide on the following pages. Refer also to Table 11 for weight and numbers caught. Of note:

- Harvest of Cod, Haddock, and Pollock was negligible with the Nordmore grate and the grate demonstrated clear size selectivity.

- Harvest of American Plaice and Grey Sole was significantly reduced with the Nordmore grate and the grate demonstrated limited size selectivity.

- For White Hake, length frequencies were not recorded during tows with the Nordmore grate. The catch of White Hake during tows with the grate were negligible.

- Harvest of Redfish was significantly reduced with the Nordmore grate and the grate demonstrated size selectivity.

- Harvest of Silver Hake/Whiting was reduced with the Nordmore grate, but was still substantial. The Nordmore grate did not provide size selectivity with the size whiting present in the area.

- Harvest of Red Hake was reduced with the Nordmore grate and the grate demonstrated size selectivity.

- Harvest of Spiny Dogfish was negligible with the Nordmore grate and the grate demonstrated clear size selectivity.

SHRIMP CATCH DATA:

The May, 2001 Experimental Shrimp Fishery shrimp catches (total for all trips of 2,025 lbs.) were disappointing and deserve discussion. The northern shrimp ((*Pandalis borealis)* lives for about five years in the Gulf of Maine. Most of these shrimp hatch out while the egg-bearing females are inshore during the winter. The larvae and juveniles remain inshore for one year and start migrating offshore between their first and second year. The shrimp mature first as a male at age two and mate during the summer at age two and a half while offshore. They remain offshore and go through a year of transition and become a female at age three, producing eggs the following summer and migrating inshore to release their larvae at age four. Then they migrate back offshore, mate again and migrate inshore again at age five. Few shrimp live beyond age five.

Each year class of shrimp remains offshore from the time it matures as a male at age two and a half until the time it is carrying eggs as a female at age four. Thus each year there is one year class of shrimp that remains offshore and does not migrate. This offshore 'resident' year class represents the primary year class that is fished for in the offshore spring fishery. To the extent that the females returning offshore in the spring arrive in the offshore shrimp beds, and to the extent that the new males have moved offshore in the spring, they, too will become a part of the spring fishery. The timing and the rate of these migrations determine the year class composition of shrimp in the offshore beds in the spring fishery.

In May, 2001, the offshore 'resident' year class of shrimp was the 1998 year class, which has consistently been the weakest year class observed in the entire history of the summer shrimp survey, 1983 – 2000. Thus there were comparatively very few offshore 'resident' shrimp available to the May, 2001 Experimental Shrimp Fishery. The April 16 – 30, 2001 spring shrimp fishery showed shrimp being caught unusually close to shore. The fishermen that fished out near the 25600 Line caught very few shrimp. Thus the offshore spring migration of females was delayed later than normal. This combination of very low resident shrimp and the delayed migration produced the low landings reported in the May, 2001 Experimental Shrimp Fishery (Table 2).

Under more normal conditions, May fishing will produce approximately 180 pounds of shrimp per hour towing (vs. the Experimental Shrimp Fishery average of 7.2 pounds of shrimp per hour towing), with a three-day trip landing as high as 8,000 pounds of shrimp (based on MEDMR port sampling records). Were this more typical rate of shrimp catch to have been observed during the experimental fishery in May, 2001, landings would have been closer to 50,000 pounds of shrimp rather than the 2,025 pounds actually caught.

The length frequencies of the Experimental Shrimp Fishery catches substantiate this year class analysis (see Figures 8 –11 on following pages). During the first two trips that occurred during May 7 - 13, most of the shrimp present were first year female or females that have not yet spawned, i.e., members of the 1998 year class (Figures 8a – 8c and 9a – 9b on pg. 19-20). There were relatively few spawned females, i.e., members of the 1997 year class, and almost no males, i.e., members of the 1999 year class. During the second set of trip pairs, May 23 through May 29, larger percentages of spawned females started showing up and larger catches of shrimp were also recorded (Figures 10a – 10c and 11a – 11c on pg. 20-21). The males, members of the 1999 year class, had still not shown up in significant numbers. The 1999 year class is much larger than either the 1998, or the 1997 year classes and will dominate catches over the next two years.

CONCLUSION:

The goal of this Experimental Shrimp Fishery research project was to determine whether a shrimp fishery can be conducted southeast of the Loran 25600 line within acceptable bycatch limits in order to provide additional economic opportunity to the shrimp fleet and alleviate pressure on shrimp in inshore waters.

Bycatch in tows using the Nordmore grate was statistically well below the 5% threshold for regulated species, despite minimal catches of shrimp. Comparative bycatch and CPUE data from Nordmore grate tows vs. control tows without the grate indicate that the Nordmore grate was effective at minimizing bycatch of regulated species present.

The low catch of shrimp was disappointing. It was the result of the small 1998 year class of male shrimp (smallest on record since 1983 inception of the summer ASMFC Shrimp Survey) and a delayed offshore migration of female shrimp. In a "normal" year for the May shrimp fishery, Maine Department of Marine Resources port sampling records indicated that shrimp catch per unit effort would be closer to 300 lbs./hr. If a shrimp fishery was permitted during May outside of the Loran 25600 line, market forces would

prevent such a fishery from occurring in years like 2001 when a small resident year class of males and/or a delayed offshore migration of female shrimp make the offshore harvest of shrimp uneconomical.

Despite the low shrimp catch, bycatch results from the Experimental Shrimp Fishery indicate that a shrimp fishery could be conducted southeast of the Loran 25600 line within acceptable bycatch limits and with a minimal impact on regulated species in terms of total weight caught and discarded.

Literature Cited:

Zar, J. H., Biostatistical Analysis. Prentice-Hall, Inc. Englewood, N.J., 1974.

Exhibits A – D: